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COST AND VALUE OF SERVICE IN RAIL-ROAD RATE-MAKING

SUMMARY

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THE main concepts in the theory of railroad rates are fairly well established, but the relative importance of these concepts is a matter demanding further investigation. It is a commonplace to say that cost of service and value of service should be considered in the making of rates; but if the theory of rates is to be put to the best practical use, we should be in a position to say how much of a given rate represents cost of service and how much value of service. This phase of the subject of rates is to be considered in the present article.

I

GENERAL VIEWPOINT

It is customary among German writers to begin the discussion of the principles governing the making of railroad rates by mentioning various possible general

viewpoints.[1] Thus, transportation might be made free, just as the use of the streets is free. This obviously would be inequitable and wasteful. Secondly, a fee might be charged to cover a part of the expense of operation, the remaining expenses, taxes, and interest being met from the proceeds of taxation. This would encourage the widest possible use of the transportation system, would prevent the transportation which is entirely useless from the public standpoint and would make unnecessary an elaborate classification of traffic such as we now know. Thirdly, we have the operation of a road as a public enterprise, the aim being to cover all costs (including return upon capital) but with public service as the dominant motive, and fourthly, there is the private undertaking with a maximum profit as the dominant motive.

It has been asserted that there is no difference between the third and fourth types of administration, since private ownership is nowadays accompanied by government control which curbs the desire for profit and compels a regard for the public interest. This is not the place to enter into the question whether the public interest is on the whole better served by public ownership and operation or by publicly controlled private ownership and operation; but it seems clear that the ideal rate system that should be enforced by representatives of the public is the same in both cases. There can be no dispute as to the result to be achieved, which is to promote the widest use of the railroad at the lowest cost with due regard for the prevention of waste. The total amount of revenue to be contributed by the entire traffic should be sufficient to cover operating expenses, taxes, rents and a

[1] For example, Ulrich, Franz, Das Eisenbahntarifwesen, Berlin und Leipsig, 1886, pp. 18–26; and Cauer, Wilhelm, Betrieb und Verkehr der Preussischen Staatsbahnen, Zweiter Teil, Personen und Güterverkehr der vereinigten Preussischen und Hessischen Staatsbahnen, Berlin, 1903, pp. 488–492.

return upon investment. The return upon the investment may have to be somewhat higher under private ownership than under government ownership because of the greater risk to capital under the former, but some return upon capital should be secured even under government ownership to prevent wasteful extensions of railway facilities. If new railway investments in the long run do not return as much as the prevalent rate of interest on well secured long time loans, the inference is that the money could have been invested somewhere else to meet more important needs, unless it can be shown that the public derives benefits from the investment which are not to be measured in terms of money. It may be wise to have expensive architecture in railway bridges and buildings as a matter of public education, and possibly very low fares which contribute nothing to capital might be justified for workingmen as one means of meeting the problem of unemployment. It is not intended to exclude considerations such as these as supplementary to the statistical processes to be explained below.

It should further be stated that the influence of competition, both between various transportation agencies and between rival producing centers is one of the practical considerations which may modify the *prima facie* reasonable rate in particular instances but which is not to be considered in getting the ideal rate from the public standpoint. We assume in what follows, monopolistic control. Again, it is likely that the various roads in a particular region will show different theoretical rates. It is for practical judgment to say whether these shall be averaged or whether a particular one is to be selected as representative. Such situations have frequently been described and disposed of by the Interstate Commerce Commission in its decisions.

The theoretical rate also will vary from division to division on the same road, but this need cause us no concern. The divisions of a railroad within a given rate territory would be considered as a unit. In theoretical rate statistics it is not necessary to be more refined geographically than traffic men are in their construction of rates. The difficulty exists, however, that a railway system frequently extends over several rate territories, while the financial and operating statistics are not similarly divided. This may be overcome by a suitable revision of our statistical reports.

II

Preliminary Survey of a Railroad's Income and Outgo

In order to have concretely before us the subject matter with which we are dealing, it may be well to summarize the entire income and outgo of a railroad and also survey the work it performs. For this purpose we choose a road of simple organization, the Chicago, St. Paul, Minneapolis and Omaha. The following statistics are from the preliminary abstract of the statistics of common carriers for 1914.

Chicago, St. Paul, Minneapolis and Omaha (1914)

Income:		Outgo:	
Freight Revenue	$11,427,563	Railroad Operating Expenses	$12,632,571
Passenger, mail and express	6,275,335	Auxiliary operations	201,546
Miscellaneous operating revenue	289,473	Taxes	973,283
Auxiliary operations	217,713	Rentals, etc	561,573
Miscellaneous rents and interest	233,405	Interest on Funded Debt	2,052,901
		Dividends	2,086,910
Total	$18,443,489	Total	$18,508,784

Excess of outgo, not including profit and loss adjustments, $65,295

Services to the public:		Operations required:	
Revenue passengers carried (passenger-miles, 266,685,999)	4,881,961	Locomotive-miles, revenue and non-revenue	11,321,817
Tons of revenue freight (ton-miles, 1,294,143,291)	8,466,632	Car-miles, revenue and non-revenue	134,936,006

To connect this statement with our present problem, it may be observed that the revenues shown in the first column are paid by the public in return for the services indicated, and the outgo shown in the second column is necessary for the operations required to perform the services. The word cost has been avoided in this connection because it has no definitely accepted meaning. Some writers look upon cost as covering only a part of the operating expenses, others make it cover operating expenses, others include taxes with operating expenses, others include operating expenses and a part of interest charges, and finally some make it equivalent to operating expenses and the full return on capital. We shall see in the next section what part of the rate may properly be called the cost element and what part the value of service element. If it were possible to trace the connection between the particular service and particular portions of the outgo, we could solve the rate question by simply charging each service with the outgo it occasioned. But the connecting of service and outgo is not possible for all the items of outgo. If possible at all it can be done only by a somewhat complicated process. The analysis of the relation between the items of outgo and service rendered is the gist of the economic theory of railroad rates.

III

Is a Railroad an Industry of "Increasing Returns"?

An industry of increasing returns is one in which an increase in the volume of business done by a given enterprise results in a reduction in the cost of performing a unit of service. This may result, on the one hand, from the fuller utilization of an existing plant, or, on the other hand, from the substitution of a more efficient plant for

a less efficient one in so far as this is dependent upon a mere increase of traffic. There is a clear gain from having the existing cars, locomotives and tracks of a road utilized to their fullest capacity. But when a single track road has become congested the gain from this source ceases. If a parallel road were then built with the same sized cars and locomotives, the same process would be repeated and in the long run the industry would be one of constant costs. But as the traffic increases, the entire plant is not duplicated. A double track is substituted for a single track, heavier rails are laid, and larger cars and more powerful locomotives are purchased. Here is a new source of gain distinct in kind from the former. Doubtless there are also limits to this kind of economy and perhaps that limit has been nearly reached on a number of roads of densest traffic.

Of these two kinds of economy that have made the railway so conspicuously an industry of increasing returns, it is the former, the fuller utilization of a large existing plant, that writers have had in mind when they have spoken of railway expenditures as divisible into constant and variable. Take for example a paragraph from Sax:

> A closer examination of the cost elements which have been distinguished shows at once that with a given degree of intensity of traffic they require a certain minimum outlay, from which point the cost does not grow in exact proportion with the traffic, but lags behind the latter. This is true historically of individual roads and geographically in the comparison of roads of varying degrees of intensity of traffic, and results especially from the fact that certain elements of cost, within wide limits, are independent of the frequency of the traffic, while others vary with the volume of the traffic. A similar condition exists with respect to other fixed plants, but not to the same degree as in the case of railroads, and this is true partly on account of natural influences and partly on account of the economic position of railways.[1]

[1] Sax, E., Verkehrsmittel, vol ii, p 363 Vienna, 1879

He goes on to say that the diminished cost resulting from a growth in traffic cannot go on *in infinitum* but comes to an end when a given plant approaches the limit of its capacity. Very generally we find that writers who expound the gain from a fuller utilization of existing plant, qualify their statements, admitting that it holds only within limits, and then they proceed to neglect the qualification. For example, Rank, after explaining these limits,[1] distributes all return on capital on the basis of ability to pay. The writer believes that there has been an overemphasis of the gain which results merely from a more complete utilization of plant and that the gain which has been realized from more improved methods, such as the use of heavier locomotives, is the more important after railroads have passed the stage of infancy. Perhaps we have here an illustration of the fact that to a considerable extent economic theory is a reflex of past economic conditions because a theory once generally accepted persists long after the conditions which have produced it have changed.

The distinction between these two classes of economy is illustrated by the fact that a road of moderate density may employ as large locomotives as one of the greatest density but not so many of them. It is not clear that the train loads of coal on the Norfolk & Western would be increased even with a large increase in that class of traffic. In other words, it is customary for any road that has attained considerable traffic to load its engines to their capacity in the direction of heavy traffic. But still, a considerable density must be achieved before the largest locomotives are justified so that this source of economy must be regarded as in part due to a mere increase in traffic.

[1] Rank, E , Eisenbahntarifwesen, p 321 Vienna, 1895

While it is desired here to emphasize the limits to these two sources of economy, it cannot be denied that they together have operated conspicuously in the past and are still in operation. The importance of recognizing the existence of these limits will be apparent when it is realized that the greater the economy to be regarded as resulting from a mere increase in traffic, the greater is the proportion of expenses which may be considered as fixed or independent of that traffic and the greater will be the scope to be given to the ability to pay element in rate-making, and on the other hand, the smaller the reduction in cost (counting return on capital among costs) per unit of traffic, resulting from a mere increase in traffic, the greater becomes the justification for cost of service rate-making. This point will be made more clear below. We must proceed, therefore, to inquire more closely into the economy resulting from a mere increase in traffic. We may note here that many influences not peculiar to the railroad industry may have a marked influence on railroad average costs. Labor-saving inventions and increases or decreases in wages and prices are illustrations. These modifying influences do not directly concern us in the theory of rates because they may affect any class of expenditure, those directly as well as those remotely related to the traffic, although they make difficult an historical comparison of the relation between traffic and expense.

The examination of the statistics of almost any road will amply demonstrate that practically no great class of expenses is unaffected by the growth in traffic. Below are given data for the Philadelphia, Baltimore & Washington system for fifteen years. The miles of line have remained practically constant, but additional tracks had to be built to take care of the expanding traffic. The traffic taken as a whole has more than

doubled, but so have total operating expenses. Investment and maintenance of way have not increased so rapidly but they have by no means remained constant. The operating expenses added to 6 per cent on the investment still show over 100 per cent increase. Considering the increase in wages there has doubtless been a gain from the mere increase of traffic, especially when the quality of the passenger service is taken into account, but one cannot study a table such as this and speak of interest charges as being fixed expenses which have no relation to the traffic.

PHILADELPHIA, BALTIMORE AND WASHINGTON R. R.
TRAFFIC, INVESTMENT AND EXPENSE
1900–1914 [1]

Year	Miles of Line Operated	Miles of all Track	Investment	Passenger Miles	Ton-Miles	M of W & St.	Total Operating Expenses	Six per cent on Investment plus Operating Expenses
			Millions	Millions	Millions	Thou'ds	Thou'ds	Thou'ds
1900	729	1,182	$43.94	234.7	481.1	$1,876	$7,547	$10,183
1901	717	1,185	43.53	246.9	496 6	1,843	7,814	10,426
1902	717	1,214	41.44	256.2	539.0	1,748	7,943	10,429
1903	710	1,279	47.12	288.3	608 1	1,724	9,027	11,854
1904	707	1,326	50.46	292 3	669 1	1,618	9,820	12,837
1905	707	1,337	52.19	308.2	691.3	1,592	10,295	13,426
1906	707	1,351	56.17	327.8	761.3	1,783	10,865	14,235
1907	707	1,388	59.22	360.6	841 5	2,037	12,453	16,006
1908	714	1,418	60.91	370 5	857 4	2,108	12,861	16,515
1909	716	1,423	61.71	355.2	895.0	2,181	12,638	16,340
1910	717	1,398	64 66	366.5	1,058.5	2,698	13,668	17,548
1911	713	1,414	66.20	387.7	1,120 1	2,770	14,641	18,613
1912	713	1,424	66.69	399.3	1,081.8	2,708	15,007	19,008
1913	713	1,432	69.27	442 0	1,252 5	3,416	17,073	21,229
1914	717	1,467	71.23	435.9	1,220.6	3,198	17,110	21,378

[1] From an exhibit submitted on behalf of this company in a case before the Interstate Commerce Commission (Docket 7730)

One would hardly attempt from a mere historical statement of this kind, even if extended to cover many other roads, to draw a conclusion as to the extent of the gain from a mere increase in traffic, since there are many other influences at work tending to increase or decrease costs. A somewhat more reliable evidence comes from a comparison of roads of varying densities at the present time. This eliminates those changes in wages, prices and new methods which are common to all roads. But in this case also we cannot expect absolutely definite results because of the varying traffic conditions, geographical variations in wages and prices, and differences in efficiency of management prevailing on various roads.

The first thing that strikes us is that very great variations in traffic density may take place without any marked difference in the expense per unit of traffic, altho the statistics available probably warrant the common opinion that with an increased density the tendency of the average expense per unit is downward. Doubtless there is a limit somewhere, but it has been asserted that with sufficient density, a cost of one mill per ton-mile could be attained.[1] Without disputing the downward tendency, it seems necessary to have a clear notion of the rate of progression downward. Let us first compare the large roads in the eastern, southern and western districts. Table I following shows the estimated operating expenses for various units of freight traffic and also the density of traffic measured by the same units:

[1] Ripley, W Z., Railroads, vol i, p 85.

TABLE I

Operating Expense and Density of Traffic, Large Railroads, 1914, by Districts

Item	Eastern District	Southern District	Western District
Freight Traffic per mile of line operated			
Net ton-miles (millions)	2.45	1.18	0.74
Gross ton-miles [1] (millions)	5.36	2.73	1.81
Loaded car-miles [2] (thousands)	104.56	55.40	39.94
Loaded and empty car-miles, including caboose (thousands)	161.54	86.11	58.83
Estimated average operating expense [3] *for a 200-mile haul*			
Per net ton-mile (mills)	4.14	4 80	5.99
" gross ton-mile (mills)	1.88	2 07	2.44
" loaded car-mile (cents)	9.65	10.20	10.96
Loaded and empty car-mile (cents)	6.25	6.56	7.44

It will be seen that the difference in density is greater between the south and the east than between the south and the west, but this is not true of the operating expense per unit. The similarity in the car-mile expense in eastern and southern districts in spite of the difference in density is also of interest. The indication is that the economy of having more car-miles per mile of line within the limits represented by the table is about offset by the added cost of hauling and repairing heavier cars, leaving the greater load in the car as a net gain. We are obviously handicapped by the lack of a homogeneous unit of service. A

[1] Includes weight of cars and contents but not of locomotives Freight car-miles in revenue service, not including special car-miles, were multiplied by an assumed weight of 18 tons and the net ton-miles added to the product

[2] Freight car-miles in revenue service, loaded, not including special car-miles

[3] Total freight expenses approximated by multiplying freight revenue by operating ratio for all business — No allowance made for switching and miscellaneous revenue Equation for a 200-mile haul made by assuming that initial and terminal services combined are equivalent to an 80-mile road haul The average haul as reported is not always reliable because of possible duplication of tonnage on the same road.

net-ton of coal traffic cannot be compared with a net-ton of excelsior, and a car of coal containing 50 tons cannot be compared with a car containing 10 tons of household goods. The gross ton-mile, which combines the tare-weight of the car and contents, is, for the same length of haul, the nearest comparable unit of service that we have, although even a gross ton-mile of a lightly loading commodity probably represents a more costly service, when density of the traffic is the same, than a gross ton-mile of a heavy commodity.

To look at the relation between outgo and traffic density comprehensively, let us examine the table and chart covering the larger roads in the preliminary abstract for 1914. (See Table II and Chart A.)

It will be seen that when the density of traffic is plotted along one axis and the gross ton-mile operating expense along another, each mark representing a road, a curve may be discerned which descends rapidly at first and then gently. What this curve seems to tell us is that for a time an increase in traffic density results in rapidly declining costs per unit of traffic, but when a density of four million gross ton-miles per mile of line is reached, the decline is very gentle thereafter. But we must be careful not to jump at conclusions here. It happens that increased traffic density per mile of line has been accompanied by an increased trainload and carload and a high percentage of mine products. Not every increase in traffic per mile of line decreases the expense corresponding to the curve shown in chart A. Obviously the extent of the reduction in expense is affected by the extent to which it permits of an increased trainload or carload. Compare, for example, the data in Table II for the New Haven and Boston & Maine on the one hand with those for the Vandalia and C. H. & D. on the other. Nevertheless, among roads of similar

TABLE II

Freight Operating Expenses and Density of Traffic for Roads having Operating Revenues of more than $10,000,000, 1914[1]

Road	Freight Gross Ton-Miles per Mile of Line	Estimated Operating Expense per Gross Ton-Mile for a 200-Mile Haul	Road	Freight Gross Ton-Miles per Mile of Line	Estimated Operating Expense per Gross Ton-Mile for a 200-Mile Haul
	(Millions)	(Mills)		(Millions)	(Mills)
Penn R. R	10 9	2 02	Atl Coast Line .	1 4	2 53
New York Central	7 0	1 89	Ch & Ohio	5 9	1 57
Balt & Ohio	6 3	1 96	Seaboard Air L	1 4	2 45
N. Y , N H & H	3 0	2 87	Central of Ga	1 2	2 73
Penn Company	8 9	1 48[2]	Mobile & Ohio	3 5	2 16
Lake Shore	7 6	1 71	Nashv , Ch & St. L	1 9	2 72
Erie	7 2	1 83	Yazoo & Miss V	1 9	2 19
Boston & Maine	3 0	2 64	C , N O & T P	8 1	2 19
Phila & Reading	10 0	1 79	A T & S Fe	1 9	2 74
Pitts , C C & St L	7 3	1 76	C B & Q	2 3	2 17
D L & W .	9 1	2 01	So Pacific	1 8	2 91
Lehigh Valley .	7 8	1 99	C M & St P	2 1	2 20
C C C & St. L	4 4	1 95	C & N W	1 9	2 22
Mich Central	4 7	1 87	Great No	1 9	2 32
Wabash	3 3	2 07	No Pacific	2 0	2 48
C R R of N J	8 1	1 81	C R I & P	1 7	2 52
D & Hudson	6 9	1 88	Union Pacific	2 7	2 48
Ph B. & W	4 3	1 87	St L & S F	1 6	2 67
Pitts & L E	16 6	1 56	Iron Mo	2 2	2 18
Pere Marq	1 8	2 60	M K & T	1 4	2 71
C & E Ill . .	3 6	1 90	M St P & S Ste M	1 6	2 11
No Central	7 1	1 74	Mo Pacific	1 5	2 61
Long Island	7	2 71	D & R G	1 3	3 04
N. Y , Ch. & St L	8 5	1 71	Oregon Short L	1 7	2 63
Maine Central.	1 5	2 23	Texas and Pacific	1 9	2 65
Vandalia .	3 0	1 80	C , St P , M. & O	1 8	2 39
El J & Eastern	3 7	1 51	Oregon—W R & N Co	1 1	3 32
Buffalo R & P	6 4	1 72	Ch Great Western	2 2	2 43
C H & D.	2 9	2 07	Ch & Alton	3 4	2 07
Southern Ry .	1 8	2 41	G C & S Fe. . .	1 7	2 73
Illinois Central	3 9	1 92	G H & San A	1 8	2 86
Louisv & Nashv.	2 7	2 34	Kansas City So	2 9	2 32
Norfolk & W.	8 9	1 53	San P , L A & S L.	1 3	3 07

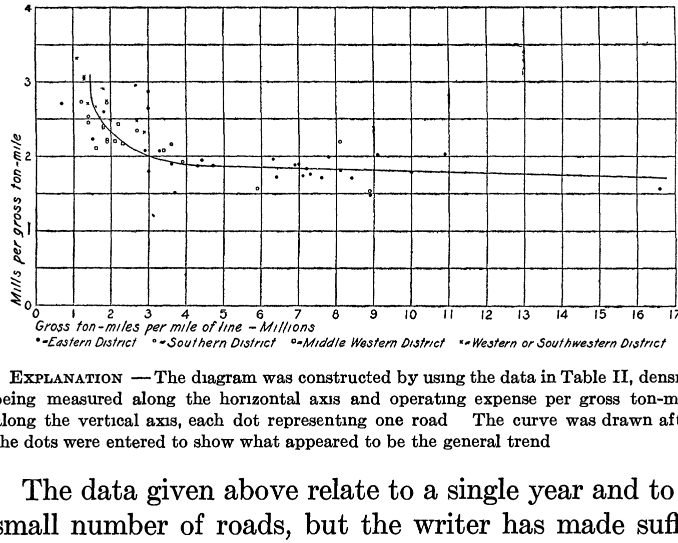
[1] Explanation of terms as in Table I

[2] On basis of 2 16 mills for an average haul of 77 miles, which may be too low.

composition of traffic doubtless some such relation of density of traffic and cost per unit as is indicated by the diagram will hold.

CHART A

Relation of Density of Traffic and Operating Expense per Unit of Traffic



EXPLANATION — The diagram was constructed by using the data in Table II, density being measured along the horizontal axis and operating expense per gross ton-mile along the vertical axis, each dot representing one road The curve was drawn after the dots were entered to show what appeared to be the general trend

The data given above relate to a single year and to a small number of roads, but the writer has made sufficient additional studies to show that a similar table covering a series of years and all roads would not greatly modify the diagram. It will require a considerable development of cost statistics to permit of more definite conclusions than is possible from the crude methods above adopted. It will be assumed for the purposes of this article that the law of the relation between density of traffic when formulated will be in harmony with the view that the gain from a mere increase in traffic is greatest in the earlier stages of railroad development and that the average operating expense per unit of the same kind of traffic tends to be a constant when a density of traffic has been reached which prevails on the

leading roads in the eastern district today. Furthermore, it is believed that a similar statement may be made concerning the capital cost per unit of traffic. Until the valuation of railroads is completed we cannot test this aspect of the matter satisfactorily, but a study of net operating revenue per ton-mile gives a curve similar to the one shown in chart A.

If this view is correct, some important conclusions follow. In the eastern district cost of service must be considered the chief consideration in rate-making and value of service a minor element, while in the south and west value of service is properly a somewhat more important element temporarily. This follows from the fact that when expenses grow less rapidly than the traffic, a portion of the expenses may be looked upon as absolutely independent of the traffic and a portion as varying exactly with it. Thus, to use Acworth's illustration, if a three-fold increase in traffic causes a two-fold increase in expense, we may regard one-half the expenses as independent of the traffic, and one-half as varying three-fold with the traffic, since one-half plus three times one-half is two. If a three-fold increase in traffic causes the expense to grow 280 per cent, the constant element would be only 10 per cent.

The constant element represents the scope for value of service, since new traffic may be economically invited without regard to the constant expenses, the burden of which should be distributed over the traffic which can best bear it. This has been explained by many authors.[1]

[1] J M Clark, in his Standards of Reasonableness in Local Rate Discriminations, has criticized the writer for saying that the distinction between constant and variable expenses is not the same as that between special and general expenses, altho the two are related. He says they are the same Sax long ago denied that they are the same, and said that when we are speaking of constant and variable expenses in relation to traffic we have in mind use units (passenger-miles and ton-miles), while when we speak of general and special we must have in mind operating units such as train-miles, because one can trace practically no expenses directly to a passenger-mile but one can do so with respect to entire trains. Sax was on the right track but did not state the matter fully

When the appropriate spheres of value of service and cost of service have been determined for each rate territory, the percentages found should be regarded as applying generally to all the large groups of outgo, to capital charges, maintenance of way, and transportation expenses. This is contrary to convention and might seem to be out of harmony with the data given on a previous page for the Philadelphia, Baltimore & Washington where the maintenance of way outlay and capital charges increased less rapidly than the rest of the operating expenses. But it should be considered that the most marked increases in wages have been among the higher classes of equipment and transportation employees. Great economies have been realized in the transportation department which have been made possible by a growth of traffic. For this reason, and because of the practical difficulties of proceeding otherwise, the percentages found will be regarded as applying generally to capital charges and to all classes of operating expenses.

This will also hold for taxes. Certainly traffic growth has actually brought with it a growth in taxes. As traffic causes an expansion in property investment, taxes on the property basis will also increase. There might be justification for distributing taxes entirely to various classes of traffic on the basis of ability to pay, since the faculty principle is the most generally accepted principle of taxation theory. The fact that the state does

enough The constant and variable expense distinction implies that a series of years is under consideration and becomes definite only when a period of time is specified The distinction between general and special becomes clear only when a unit of traffic is specified, be it the ton, the car, or the train, or groups of trains, and the term special includes more or less of the expenses according to the size of the unit It is true that the expenses which are most markedly special are also mostly markedly variable, that is, those which can be attributed to a particular car will also increase with a comparatively small increase in traffic To dispute as to whether this makes the two concepts the same would be a quibble, but we certainly have two quite different viewpoints of the same thing at least.

not levy all railway taxes on this basis is no reason why an ideal rate system should not pass the burden on in a different manner. But to avoid dragging in the theory of taxation, it would be better to make no separate treatment of taxes.

IV

Bridging the Gap between Theory and Practice. Review of Selected Authors

Assuming the conclusions in the foregoing section to be accepted, how can we make a rate on the basis of them ? The answer is that it involves on the one hand a process of what is often called cost accounting (better named statistical cost analysis), and on the other hand a process of assessment to cover the contributions according to ability to pay. Many attempts of this kind have been made of varying degrees of completeness, and it may be of service if a number of these are summarized. The writers selected here are not the best known authors on railway rates. The reason for omitting Sax, Ulrich, Colson, Hadley, Taussig and Ripley is that these writers do not translate statistics into rates, whereas those here selected do so.

In 1890 Launhardt [1] contributed three articles to the *Archiv für Eisenbahnwesen*, two of which are general for all classes of traffic, the third dealing in particular with the construction of passenger fares. It is the last of these that especially concerns us at this time. He first makes definite the distinction between constant and variable costs. Among the former, that is, those dependent on the volume of the traffic, he includes the transportation operating expenses, 10 per cent of general expenses, and the renewal of rails and switches, the

[1] Launhardt, W , "Theorie der Tarifbildung der Eisenbahnen," Archiv fur Eisenbahnwesen, (Berlin) 1890, pp 1, 161, and 911

maintenance and renewal of equipment and the interest on the investment therein. Strictly, he says he should also include the investment in freight warehouses and shops, switching tracks, and the like, as varying with the traffic. He does not find it practicable to do this and so arbitrarily rounds off his results upward in getting his final variable costs. He then divides expenses between passenger and freight, not by individual accounts, but by comparing operating results on various railway operating divisions which have varying proportions of freight traffic, using algebraic formulae. He then finds the cost of axle kilometers and train kilometers, subdividing the train costs into those which are independent of the number of axles and those which vary with the number of axles, separately for freight and passenger. In this way he gets a varying cost for trains of different lengths. By finding the number of passengers per axle for the various classes of passenger traffic he finds the average cost per passenger-kilometer. So far he has dealt only with the variable costs. The constant *operating* cost (not including interest) he finds to be 6540 marks per kilometer for the average of the Prussian system, but he finds that various operating divisions show the constant cost to vary, being 10,000 in one case and 5,800 in another. These divisions are widely different in density of traffic, that is, the so-called constant expenses themselves vary with the traffic more or less.

Launhardt does not proceed to distribute the constant expenses to the various classes of traffic. The variable expenses give him simply the lower limit of the rate for each class of passenger traffic. The highest limit he then determines by the effect of various rate levels on the volume of traffic. For this purpose he formulates a law of travel, finding the number of persons who will travel specific distances at a particular rate, and then he

determines the rates which are most advantageous to the railway administration in yielding the highest net surplus over cost. He finds that the fares then existing were too low for short distances and too high for long distances.

For the benefit of the intending reader of Launhardt it may be noted that his articles bristle with mathematical formulae. These articles are noteworthy because of their rigid adherence to fundamental economic principles, altho some of the assumptions may not be warranted.

A treatise published by Rank [1] in 1895 contains in addition to a review of the theory of rates a detailed analysis of railway statistics from the standpoint of cost. He makes a sharp distinction between the cost element and the value of service element in rate-making. The cost element he restricts to those operating expenses which grow directly from the performance of a service. Thus interest and amortization are omitted. These, in his view, are profit, not cost. The operating expenses he thinks can, without great error, be divided according to service units while the profit requires more or less exclusive consideration of ability to pay.

He first divides all operating expenses between station expenses and distances expenses. He does this by groups of accounts. The next step is the division between passenger and freight. This separation is made account by account in the manner which has become familiar here in rate cases since the Buell case in Wisconsin.

The cost of a particular service is found by first ascertaining the axle-mile distance costs for the particular type of train and dividing by the passengers or tons per

[1] Rank, Emil, Das Eisenbahntarifwesen in seiner Beziehung zu Volkswirtschaft und Verwaltung. Vienna, 1895.

axle. To this distance cost must be added the station costs, independent of distance, which are assigned equally per unit, that is per passenger and per ton, respectively. The variation in the net to the tare load is taken account of in the case of the distance costs, but apparently not in the case of the station costs.

He then passes on to the discussion of the distribution of the profit. He does not specifically divide this as between passenger and freight by a formula. It will be a matter of experience, he thinks, as to what each branch of the traffic can bear. He would spare the passenger traffic as much as possible as the latter has the greater elasticity of demand. In general he would make the profit decrease relatively with the distance, in both freight and passenger traffic. As the value of service cannot be directly measured, he would make the selling prices of the goods the measure instead (at the point of cheapest production). This portion of the subject is treated at length, but not statistically.

A little book written by an American railroad official in 1904 is of interest in this connection.[1] He finds that if accounts are properly kept we can get an actual distribution as between passenger and freight of "probably not less than seventy-five per cent of the [operating] expenses." The remainder he thinks can reasonably be alloted on the basis of gross ton-mileage, which he thinks is the nearest approximation to an absolute unit of service in transportation. By keeping suitable accounts on a southern railway for a ten year period, (1875–1884) he found the gross ton-mile operating expense for passenger service to be 4.34 mills and for freight service 3.24 mills. He found that for the same period under similar conditions there was little variation

[1] Talcott, T M R, Transportation by Rail. An Analysis of the Maintenance and Operations of Railroads Richmond, Va, 1904

as between roads. Interest and rentals, he says, are not only a part of the cost of transportation but an obstrusive element of cost. But in reality he treats interest charges not as cost, but as profit to be distributed in accordance with the ability to pay, which is not treated statistically. It should be noted that in using gross ton-mileage to divide between passenger and freight he takes speed into account by reducing the gross ton-mileage of various trains to a speed of one mile per hour, that is, he multiplies the gross ton-miles of each class of trains by the average speed in miles per hour. A study of cost in relation to distance leads the author to the conclusion that rates should increase with the square root of the distance.

His subdivision of cost as between various classes of freight traffic is restricted to the classes, general tonnage, stone and coal, and switching. The passenger train expenses he subdivides as between passenger, mail, and express on the basis of gross ton-miles.

Incidental mention may be made here of an old cost analysis by Shinn,[1] who was for two years president of the Ashtabula, Youngstown, & Pittsburgh Railroad. He had experience in the steel business and as a civil engineer. In 1890 he was president of the American Society of Civil Engineers. The article before us is an account of a special report the author was called upon to prepare regarding the freight traffic of the Pittsburgh, Fort Wayne & Chicago, 1865–68, with a view to settling the important point as to where transportation becomes actually unremunerative and at what price it will justify an increase of facilities in order to increase the tonnage. By showing that certain expenses are independent of the growth of the traffic he was able to

[1] Shinn, W P, "Analysis of Cost of Transportation," Journal of the Railway Association of America, No 2, May, 1875

justify a very low rate. His results were at that time criticized by J. B. Jervis, a consulting engineer, in a letter dated November 22, 1866, written to an official of the Pittsburgh, Fort Wayne & Chicago, and published by Mr. Shinn. After noting that a small increase in traffic would not affect certain items of expense, he says:

> With some [expenses] the ratio would be very small, and at first sight appear to be nothing, still it may be questioned whether the experience of railways after reaching a volume of traffic that gives a pretty full occupation to regular trains has materially reduced the ratio of expense by an increase of traffic. The reduction that has taken place may be largely accounted for in the improved facilities that have been made, in superior accommodations for the repair and management of machinery, for the supply of water, and the general transaction of business that have grown up under railway experience.

It is interesting to find this early conflict of opinion as to where the line between constant and variable expenses should be drawn.

The methods worked out in the railroad commission of Wisconsin were described by Commissioner Erickson in a paper prepared in 1910 for the National Association of Railway Commissioners.[1]

At the outset Mr. Erickson lauds cost of service rate-making as more scientific than value of service rate-making, but the method which he presents is in fact a combination of cost of service and value of service. His treatment is at many points in general terms, the detail being illustrative rather than complete. So far as it can be made out from the article the theory and procedure may be summarized as follows:

There are certain fixed expenses (including a portion of the interest charges) which within certain limits do

[1] Erickson, Halford, "Freight Rates." Reprint (1914) of a paper submitted to the National Association of Railway Commissioners, Proceedings, 1910, p. 186. Compare the earlier article by Commissioner B. H. Meyer in the same Proceedings for 1907, p. 105.

not increase as rapidly as increases in the business. The fixed expenses should be borne by the traffic best able to do so. Low-priced articles should pay rates high enough to cover operating expenses, "including something in the way of net earnings." The method of rate construction advocated is to divide operating expenses and the investment charge between passenger and freight and also between terminal and line service. Freight terminal expenses are then divided by the number of loaded cars, the result being assumed to be constant for any load per car. The freight movement expense is determined per gross ton-mile for the average load per car and the gross ton-mile cost is assumed to be constant for any load per car. From these data the cost of carrying a commodity any distance can be found if the average load per car is known. Upon these average cost results is then ingrafted the existing freight classification "by determining the position of the average rate under average loading for the traffic as a whole," and the rates for the various classes are reached by using a fixed percentage relation between the classes. The average rate is found to be a little less than class C and a little more than class D in the western classification. The author recognizes that the existing classification is based on value and bulk, while ability to pay freight rates per ton rests upon the relation between value and weight.

What may be looked upon as a refinement of the method of Mr. Erickson is found in an exhibit by F. H. Millard in the Western Rate Advance Case of 1915.[1]

The total rate is divided into two portions. The cost portion is made to cover operating expenses, taxes, and rents, while the value of service element is a contribution to interest on investment. The cost computations

[1] 35 I. C. C. Reports, 497 (562, 649).

involve first a separation between passenger and freight and a division of the latter between terminal and movement service. The terminal cost was subdivided among various branches of the freight traffic partly according to the number of cars handled and partly according to the number of gross tons handled. Movement cost was subdivided among various branches of the freight traffic according to the number of gross ton-miles. Empty car-mileage was subdivided by classes of traffic, according to the mileage of the type of car used by each class of commodities. In this way cost units were arrived at from which the cost of moving any commodity for a given distance can be calculated if the load per car is known. The expense for the loss and damage of freight was considered a cost and allocated directly to each class of freight.

The contribution which each commodity must pay to cover interest charges was found as follows: Total interest (or dividends) was divided between passenger and freight in the same proportion as the expenses were divided, there being no method known of measuring the total ability of the passenger service and the freight service respectively to bear interest charges. The interest charges thus apportioned to freight were subdivided between terminal and line movement services again as the expenses were found to be divided. The subdivision by classes of commodities was achieved by classifying commodities according to their market value into twenty-four classes, the lowest containing those commodities which had a value of less than \$2 per ton and the highest those having a value over \$205. The total interest charge was then subdivided among these classes of traffic by assigning to the lowest class an amount which, if the same amount per ton and per ton-mile were assigned to all traffic, would equal 4 per cent

on the investment of the road, and the other classes were charged with other portions of the interest in such amounts that if all traffic were taxed equally with any particular class, per ton and per ton-mile, the return on the investment would have been respectively $4\frac{1}{2}$, 5, $5\frac{1}{2}$, 6, 7, . . . 25 per cent.

Millard's work is the most definite and complete that has as yet been performed in the line of attempts to derive a theoretically reasonable rate purely from statistics of railway traffic and operation. It was necessary at certain points for him to use arbitraries where further development of accounting may some day yield exact information. There are also certain points of theory which further discussion may modify.

Any one who attempts to make rates from statistics must first decide whether he will consider the value of service as between various classes of commodities. If he decides to do this he must also decide how large a scope he will give to this element. Millard drew the line by making this element cover the interest on investment. While this may have been practically justified for the roads considered, it is open to attack from the standpoint of theory. The interest charges on equipment are as closely related to the traffic as are the maintenance charges for equipment, and, as has already been shown, other interest charges are also indirectly affected by the growth of traffic. In a way this has been met in the exhibit before us by making all traffic contribute at least 4 per cent on the investment. But if this minimum of 4 per cent be looked upon as being placed upon all traffic because interest charges bear some relation to growth in traffic, then this minimum should be distributed according to the use made of the capital, that is possibly according to gross ton-miles, but not according to net ton-miles.

Again, all operating expenses cannot be looked upon as varying with the traffic. A part of them should also be distributed according to the ability to pay. As already indicated, it is doubtful whether from the social standpoint taxes can be regarded as an operating expense. They seem more closely related to the ability to pay. Again, net rents are in whole or in part payments for the use of capital.

Another criticism that might be offered relates to the distribution of the return on investment as between the various lengths of haul. In the Millard exhibit, a net-ton hauled a thousand miles is taxed ten times as much for the return on capital assigned to movement service as a net-ton of equal value hauled one hundred miles. Cost may grow with the distance but does value of service ? To a certain extent distance affects value of service. In order that the value of service of hauling oranges may be high, the haul must be long enough so they may reach a point where the climate prohibits the production of oranges. But in reality it is the difference in the cost of production, not the distance, that is closely related to the value of service. Logically, the ability-to-pay-tax to be levied on a particular class of commodities should be distributed equally per ton regardless of distance. In practice, some concession would have to be made to the short hauls because of the competition from other means of transportation.

A criticism related to the preceding is that Millard adds the ability-to-pay-tax to the cost regardless of whether that cost is high or low. If a commodity must pay a high rate because its cost of carriage is high, should not the value tax be eased up a little ? Ability to pay in rate-making should mean ability to pay freight rates, not ability to pay something in addition to the cost of carriage.

In order that statistics may become the basis for a scientific system of rates, a considerable modification in the reports now made by railways will be necessary. It is desirable that expenditures be divided by classes of traffic so far as practicable. In this connection it may be noted that the Interstate Commerce Commission has recently issued an order, effective as of July 1, 1915, requiring the larger railway companies to distinguish their freight expenses from their passenger expenses. The carriers are expected to assign to freight service or to passenger service such expenses as are directly or naturally assignable and that this direct assignment will be carried to the fullest extent that is practicable without undue increase in accounting expense. Thus, the expenditures falling under the accounts relating to car repairs, train enginemen and fuel for train locomotives are almost altogether directly assignable. On a number of roads steam locomotive repairs can be assigned directly. The order of the commission also prescribes rules for apportioning most of the items common to both freight and passenger services. Yard expenses not directly assignable, for example, are to be divided according to the number of switching locomotive mile in each service. The important accounts relating to roadway track maintenance, however, are to be recorded as undivided. Obviously we should have studies which will further segregate the expenses attributable to less-than-carload business, to fast freight lines and to the mail and express services.

Most conspicuous is the lack of adequate traffic statistics giving details as to the revenue and volume of traffic for various classes of commodities. Again, our financial and operating statistics do not conform to rate territories. It is to be hoped that the valuation of railways will give us more information as to the assignment of

various portions of the investment to classes of service, such as freight and passenger, and to terminals as distinguished from the roadway. Much detailed work must be done before a satisfactory result can be achieved, but it is important that theoretical discussion yield definite principles which shall guide those who must do the work of detail.

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